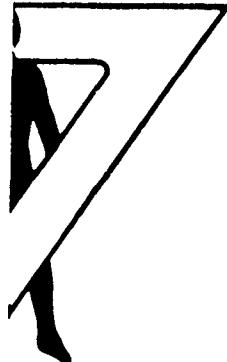


AD A 0 46620



12

AD

Technical Note 9-77

A HUMAN FACTORS EVALUATION OF AN EXPERIMENTAL REVERSIBLE
EXTREME COLD WEATHER CLOTHING ENSEMBLE

Arthur A. Woodward, Jr.
Charles A. Hickey, Jr.

AD No. _____
DDC FILE COPY

August 1977
AMCMS Code 672716.H700011

Approved for public release;
distribution unlimited.

D D C
REPRODUCED
NOV 22 1977
FOLIO 1
B

U. S. ARMY HUMAN ENGINEERING LABORATORY
Aberdeen Proving Ground, Maryland

**Destroy this report when no longer needed.
Do not return it to the originator.**

**The findings in this report are not to be construed as an official Department
of the Army position unless so designated by other authorized documents.**

**Use of trade names in this report does not constitute an official endorsement
or approval of the use of such commercial products.**

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Technical Note 9-77	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A HUMAN FACTORS EVALUATION OF AN EXPERIMENTAL REVERSIBLE EXTREME COLD WEATHER CLOTHING ENSEMBLE		5. TYPE OF REPORT & PERIOD COVERED Final r-t,
6. AUTHOR(s) Arthur A. Woodward, Jr. Charles A. Hickey, Jr.		7. PERFORMING ORG. REPORT NUMBER
8. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Human Engineering Laboratory Aberdeen Proving Ground, MD 21005		9. CONTRACT OR GRANT NUMBER(s)
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS Code 672716, H700011		11. CONTROLLING OFFICE NAME AND ADDRESS HEL-TN-9-77
12. REPORT DATE August 1977		13. NUMBER OF PAGES 24
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 12 JGP		15. SECURITY CLASS. (of this report) Unclassified
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		18a. DECLASSIFICATION/DOWNGRADING SCHEDULE
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Arctic Clothing One-Piece, Reversible Human Factors Evaluation		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A human factors evaluation was performed on an experimental two-component reversible extreme cold weather clothing ensemble (parka and trousers). The garments tested had been improved following recommendations of an earlier feasibility test; all of the improvements introduced were judged to be completely acceptable. Troop acceptance of the basic concept of the new ensemble is high. Despite this, the two new clothing items remain unsatisfactory for several reasons. These include: (a) excessive sleeve and leg lengths, (b) lack of front fly opening on trousers, (c) lack of trouser ankle		

(Continued)

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

20. ABSTRACT (Continued)

closures, (d) poor construction of parka neck for attachment of hood, (e) very poor method of button hold construction, and (f) noise and static electricity generation by the outer fabric layer of the garments. ←

ACCESSION NO. 7

RTIS	
BDC	
EXAMINER'S ID	
JUSTIFICATION	
BY	
DISTRIBUTION/AVAILABILITY CODES	
Dist.	AVAIL and/or SPECIAL
A	

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

AMCNS Code 672716.H700011

Technical Note 9-77

A HUMAN FACTORS EVALUATION OF AN EXPERIMENTAL REVERSIBLE
EXTREME COLD WEATHER CLOTHING ENSEMBLE

Arthur A. Woodward, Jr.
Charles A. Hickey, Jr.

Technical Assistance
Richard S. Bruno

August 1977

APPROVED:


JOHN D. WEISZ
Director
U. S. Army Human Engineering Laboratory

U. S. ARMY HUMAN ENGINEERING LABORATORY
Aberdeen Proving Ground, Maryland 21005

Approved for public release;
distribution unlimited.

CONTENTS

INTRODUCTION	3
TEST ITEMS	3
TEST SUBJECTS	4
CLOTHING ENSEMBLE	4
METHODS	5
RESULTS AND DISCUSSION	7
CONCLUSIONS	21
RECOMMENDATIONS	22
REFERENCES	23

FIGURES

1. Side Fastener Pull in Relation to Mitten-Encased Hand	8
2. Experimental Clothing Ensemble on Smallest Subject- Front View	10
3. Experimental Clothing Ensemble on Smallest Subject- Side View	10
4. Experimental Clothing Ensemble on Largest Subject- Front View	11
5. Experimental Clothing Ensemble on Largest Subject- Side View	11
6. Subject Ready for Urination	15
7. Buttonholes on Neckband of Parka- O.D. Side	18
8. Buttonholes on Neckband of Parka- White Side	19
9. Experimental Clothing Ensemble Worn in Camouflage Mode	20

TABLES

1. Results of Simulated Urination Tests: Summary	12
2. Simulated Urination Tests: Individual Measurements	13

A HUMAN FACTORS EVALUATION OF AN EXPERIMENTAL REVERSIBLE EXTREME COLD WEATHER CLOTHING ENSEMBLE

INTRODUCTION

This report deals with a proposed extreme cold weather clothing ensemble. The ensemble consists of two garments, each reversible so as to be wearable with the olive green (OG) color side out or with the white camouflage side out. Each garment replaces a three-component system (shell, insulating liner and white camouflage overgarment) that is the present standard issue. This reduction in the total number of components, together with the use of improved insulation materials, has resulted in a substantial decrease in weight and bulkiness of the new cold weather ensemble as compared with the system in current use. Prototypes of the new garments were fabricated and submitted by U.S. Army Natick Research and Development Command (NARADCOM) to the U.S. Army Arctic Test Center for feasibility testing. This testing was conducted in the late winter of 1974 and the results were reported in June 1974 (3).

These tests revealed a number of human factors problems, shortcomings, and deficiencies. As a result, modified versions of the garments were fabricated by NARADCOM and submitted to the U.S. Army Human Engineering Laboratory (USAHEL) for human factors evaluation. In the feasibility tests reported in Reference (3), the garments were evaluated against 17 acceptability criteria, five of which were identified as being specifically concerned with human factors (ease of donning and doffing, troop acceptability of one-piece concept, means of body elimination and fabric noise creation). In this evaluation particular attention was paid to the garment characteristics related to these criteria, especially in the case of the two criteria not met (means of body elimination, fabric noise creation). In addition, the experimental items were carefully examined and evaluated for any other potential human factors problems.

TEST ITEMS

Two specific garments were the subject of this evaluation. These are:

- a. Parka, Extreme Cold Weather (Arctic), Reversible.
- b. Trousers, Extreme Cold Weather (Arctic), Reversible.

Six ensembles of newly fabricated garments, in medium size only, were supplied for use in the evaluation. A number of modifications recommended in the report of the feasibility tests were incorporated in these garments. These included:

- a. Improved method of installing slide fasteners.
- b. Reversible buttoned strap wrist closures to replace elastic wrist bands.
- c. Outer insulation added to the parka pockets.
- d. Sewed-in parka hemline cords.

e. Front suspender loops on trousers (this change was approved and added in the field during the feasibility study).

Notably absent were two modifications recommended to deal with significant problems reported in the feasibility study:

- a. Lack of closures at the ankles of the trousers.
- b. Lack of a front fly opening on the trousers.

TEST SUBJECTS

Subjects who wore the test clothing for this evaluation were U.S. Army infantrymen drawn from line units. Preliminary observations on donning, doffing, and fit were made on a group of eight airborne troops available during June 1976. All other observations were made using a group of six men from mechanized infantry units, available January through February 1977. Both groups were involved primarily in other major tests and had to be used as available on a non-interference basis. Subject usage was further restricted to men who wore medium sizes of both military jackets and trousers, since the test items were supplied only in medium size.

CLOTHING ENSEMBLE

The subjects were dressed in a clothing ensemble comprised of standard clothing items used under extreme cold weather conditions with one exception. Since insulated cold weather boots were not available, a combination of combat boots and rubber overshoes was substituted to simulate at least partially the bulk and texture of insulated footwear. The clothing assembly used by all subjects is listed below:

Undershirt, men's, 50-cotton, 50-wool, full sleeve.
Drawers, cold weather, men's, 50-cotton, 50-wool, knit, ankle length.
Shirt, cold weather, wool nylon flannel, OG 108.
Coat, cold weather, men's, cotton and nylon, wind resistant sateen (field coat).
Liner, cold weather coat, nylon quilted, 6.2 oz., OG 108.
Trousers, men's cold weather, cotton and nylon, wind resistant sateen, olive green, Army Shade 107.
Liner, cold weather trousers, nylon quilted, 6.2 oz., OG 106.
Suspenders, trousers, scissors back type.
Hood, extreme cold weather, cotton nylon, OG 107, w/fur ruff.
Socks, men's, wool nylon cotton, cushion sole, OG 108.
Boots, combat, black leather upper, mildew resistant, plain toe, DMS.
Overshoes, high, black rubber, cleated, five buckles (sized to fit over combat boots).
Mitten Inserts, wool and nylon knit, OG, w/trigger finger.
Mitten Set, extreme cold weather, gauntlet style shell with leather palm.
Parka, extreme cold weather (Arctic), reversible (TEST ITEM).
Trousers, extreme cold weather (Arctic), reversible (TEST ITEM).

METHODS

Donning and Doffing

After indoctrination on the special features of the two test garments, each subject was required to dress in the complete clothing ensemble listed above. This process included attachment of the hood to the parka without assistance. After completion of a series of test exercises, each subject then doffed his outer clothing (parka and trousers). The eight subjects used for preliminary observations went through this procedure twice, once with the experimental parka and trousers and once with standard arctic overgarments. The six subjects used later for more extensive observations went through a similar procedure using the experimental parka and trousers only. In addition, they donned combat load-carrying gear and protective mask in carrier. This sequence was conducted with the experimental garments worn with the OG side out. Subsequently, each subject then reversed the two experimental outer garments to white side out and repeated the doffing and donning.

Each time a subject completed donning of the test clothing ensemble he was required to run the five slide fasteners on the parka and trousers up and down their full length several times.

Static Exercises

When fully dressed, each subject performed a standard set of static exercises designed to reveal areas of poor fit or restriction of movement in military clothing. These are described in detail in an earlier report (1). In brief, the exercises involved simple, maximum exertion movements from an erect position with arms hanging to the side, as follows:

- a. Stretch arms horizontally to the sides.
- b. Cross arms horizontally across the chest.
- c. Extend arms horizontally and swing them backward.
- d. Extend arms vertically, palms touching overhead.
- e. Extend arms horizontally and bend forward from the hips.
- f. Extend arms horizontally and bend backward from the hips.
- g. Extend arms horizontally and rotate the trunk around its vertical axis.

The exercises could be performed in standing, sitting and squatting postures. The subject performed each exercise several times and reported any signs of binding or restraint before proceeding to the next.

Simulated Urination

Each subject was instructed in the procedure recommended by NARADCOM (2) in lieu of providing a fly opening on the arctic trousers; that is, to zip down one side of the trousers from the waist and then pull aside the front trouser flap to gain access to the fly openings of the

undergarments. The subject was instructed to start on command, to signal when he reached the point where urination would be possible (Ready), and then to restore his clothing to the fully dressed condition. The subject was told to assume the existence of extreme cold hazard conditions and to make his own decisions on trade-off between maximum performance speed and minimum cold exposure, particularly of the hands. Stop watches were used to record total time for the exercise, time from "Start" to "Ready," total exposure time of hand (or hands) covered by wool mitten insert only, and total exposure time of hand (or hands) bare.

Each subject performed the simulation exercise once under each of four different conditions, always taken in the same order, as follows:

Condition 1: Test clothing ensemble worn OG side out, subject wearing ALICE with combat load, trousers opened by zipping down from the waist.

Condition 2: Test clothing ensemble worn OG side out, subject wearing ALICE with combat load, trousers opened by zipping up from the ankle.

Condition 3: Test clothing ensemble worn OG side out, subject wearing rucksack loaded with Radio Set, AN/PRC-77 (22 pounds), trousers opened by zipping down from the waist.

Condition 4: Test clothing ensemble worn camouflage (white) side out, wearing ALICE with combat load, trousers opened by zipping down from the waist.

Garment Reversal

After performing the urination simulation exercise under Condition 3, the subject doffed the test garments (arctic trousers and parka) and was required to reverse the ensemble from OG side out to white camouflage side out without instruction or assistance.

Test Clothing Rotation

The tests described above involved about an hour of wearing time for each subject. The test clothing ensemble was changed with each new subject in order to distribute wear evenly and to check all of the test garments supplied for uniformity of construction and fit. Each ensemble was worn at least three times but no more than four times during the evaluation tests here reported.

Data Collection

Certain specific exercises were timed as described in previous sections. The bulk of the data is in the form of logged observations. All comments made by a subject, whether voluntary or in response to direct questions, were recorded immediately. Each subject was observed carefully by two test personnel throughout each test session. Their observations were recorded during the progress of the tests and during the discussion following the completion of a test cycle by each subject. In addition to this type of record, the largest and smallest subjects used in the urination simulation exercises were asked to repeat these exercises for purposes of still and motion picture photographic recording.

RESULTS AND DISCUSSION

Doffing and Donning

No significant problem was observed or reported by subjects during the repeated donning and doffing of the test garments. A single instance of trouble starting the two-way fastener on the parka is discussed later. The subjects unanimously approved the full-length side opening feature of the trouser legs. All immediately appreciated the ease with which such trousers can be donned or doffed while wearing heavy footwear and without concern for soiling or wetting the inside of the trouser legs.

Slide Fasteners

In one instance, one subject had some difficulty with slide fastener hang-up on adjacent fabric. This involved the front closure of the parka, but the exact cause is not known because the subject was able to unjam the fastener before the observers could stop him and examine the nature of the fastener jam. One other subject had considerable difficulty inserting and starting the slide fastener on the parka. This appeared to be the result of unfamiliarity with this particular type of slide fastener and the subject had no later difficulty. The test garments were fabricated with the beading on the edges of the fastener overlays as recommended in the report on the feasibility tests (3). The improved method of construction is considered to be entirely satisfactory.

It was the consensus of all test subjects and of the observers that the nylon ribbon pulls attached to the slide fastener tabs are quite inadequate for their purpose. Except as a tour de force, these pulls cannot be grasped by an arctic mitten encased hand, as shown in Figure 1. These pulls are too short, too insubstantial, too smooth, and too flexible to serve their intended purpose (which is to provide a quick sure grasp by a hand encased in a heavy mitten that largely defeats tactile sensitivity). In addition, the nylon tapes were improperly attached to the fastener slide tabs; they should have been knotted to the tabs rather than merely looped through them. The result was that the thin, naturally elastic, 1/4" nylon tape used for the pulls hung in open loops that tended to spring away from the mitt surface on contact. There was general agreement that the slide fastener pulls used on the standard field jacket are much superior. Fashioned of 3/8" wide coarse woven tape and cut and knotted to 5" length, these latter pulls are easily located and securely grasped even by a heavily mitted hand.

Garment Fit

In the first series of tests (June 1976), eight subjects performed all of the static exercises in each of three postures: (a) standing, (b) seated in a straight-backed chair, and (c) squatting. These men wore the complete arctic clothing ensemble, except for the hood, which was intolerable even in the air-conditioned room in the summertime. They wore no load-carrying equipment. This group of subjects reported only a few instances of minor binding, associated neither with any particular garment region nor with any particular posture.

The second group of subjects (January through February 1977) performed the static exercises out of doors in standing position only. In addition to the full clothing assembly, they also wore the All-Purpose Lightweight Individual Carrying Equipment (ALICE) with assault load



Figure 1. Slide fastener pull in relation to mitten-encased hand. (Note the small size of the pull and the improper attachment to the fastener tab.)

and also an M-17 protective mask in its carrier (see Figure 2). Of these subjects, only one reported any kind of restraint. This was a small amount of "pull" in the armpit area that seemed to be due to interaction between the outer clothing and the load-carrying gear. This particular subject was the largest man in the group (see below).

These observations indicate clearly that the fit of the garments is acceptable insofar as garment cut is concerned. The lengths of the parka arms and trouser legs is another problem. Figures 2 and 3 show the test clothing assembly on the smallest of the six subjects used. This man had a 37th percentile stature, 32d percentile crotch height, and a 30th percentile shoulder-wrist length. For this man, the trousers are obviously too long and the parka arms show excessive bunching. Figures 4 and 5 show the ensemble on the largest man in the same group. He had an 83d percentile stature, 64th percentile crotch height, and a 75th percentile shoulder-wrist length. On him the trouser length is certainly not too short and the parka arms show the same excessive bunching. Too few subjects were available to allow a definitive analysis of these problems. They surely should be further investigated before development proceeds further. The trouser length problem is further complicated by the omission of an ankle closure, which is discussed later in the report.

Ease of urination

In the report on the feasibility test (5), the lack of a front fly opening in the one-piece reversible trousers was the reason this item failed to meet the criterion for "method of body elimination." The trousers supplied for this evaluation still lacked such an opening; instead, NARADCOM recommended the procedure given earlier as a solution of the problem. The simulated urination tests were designed to examine the questionable merit of this recommendation. The tests were simple in design, the sample was small (five subjects), and the performance times as such varied considerably between subjects. Still, the basic task is one performed with well-ingrained habits, the practice effect involves at most the manipulation of only one unusual garment of an ensemble of otherwise standard clothing. Despite variability, the data had consistency and the performance times were all quite high. As a result, unequivocal conclusions can be drawn concerning the matters of greatest interest. Table 1 summarizes the results of these tests; the individual measurements are given in Table 2. The values given have been adjusted by the addition of 30 seconds to allow for time consumed in actual urination, a value based on the mean of 24 field measurements.

"Total urination time" is the time from the moment the subject began to open his clothing, on signal, to the moment his clothing was completely restored to a condition of full closure and dress. In the tests performed in accordance with the recommended procedure (Conditions 1, 2, and 4), these times are inordinately long, ranging from nearly 2-1/4 minutes (146 sec.) to over 8-1/4 minutes (524 sec.). Most of these long performance times was spent with at least one hand "cold exposed;" i.e., bare or covered only by the wool mitten insert (Total Hand Exposure Time). This exposure time consistently comprised more than 90 percent of the Total Performance Time, whether one considers the mean values for each of the different conditions or the individual performance times. The actual values of hand exposure times are a matter of major concern. For the simplest of tasks (Condition 2), the mean bare-hand exposure time was 93.8 seconds; the maximum time for an individual subject was 219 seconds. Frostbite hazard is expected in 1 minute under windchill conditions that occur in the winter in temperate climates and were experienced during the second series of tests reported here. In a sub-Arctic environment, such as that in Alaska, windchill conditions of this severity are very



Figure 2. Experimental clothing ensemble on smallest subject- front view.
(Excessive lengths of trouser legs and parka arms show clearly.
Observe the impediment to opening up the clothing provided by
the straps of the ALiCE and mask carrier and by the parka leg
ties.)



Figure 3. Experimental clothing ensemble on smallest subject- side view.
(Slide fastener along side of trouser leg shows clearly. Observe
that lack of an ankle tie exposes the lower closure button and
slide fastener to fouling from mud or snow.)

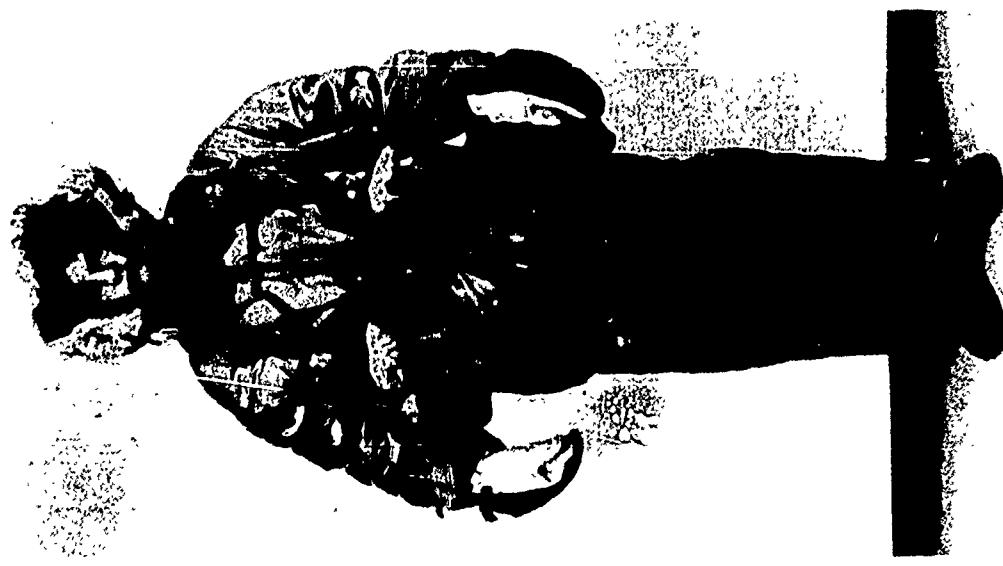


Figure 4. Experimental clothing ensemble on largest subject- front view.
(Lengths of trouser legs and parka arms are marginally acceptable for this subject, whose stature and crotch height are well above average, but whose other dimensions dictate medium size clothing.)

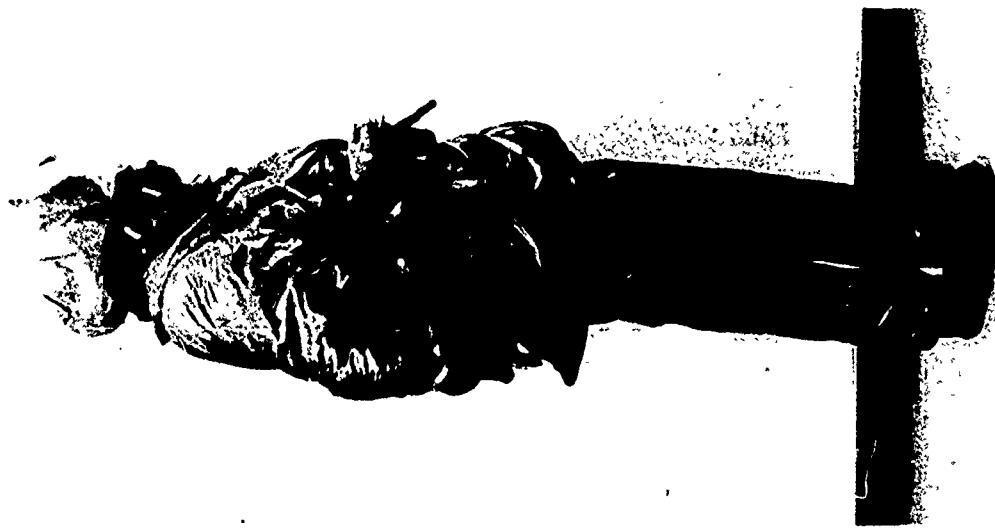


Figure 5. Experimental clothing ensemble on largest subject- side view.

TABLE 1
Results of Simulated Urination Tests: Summary

NARADCOM Procedure	Means for Five Subjects		
	Time (Seconds)	Percent of Total Time	
<u>Condition 1:</u>			
<u>Ensemble OG out</u>	374.6	100.0	
<u>ALICE combat load</u>	144.8	38.7	
<u>Zip down from waist</u>	216.4	57.8	
	128.8	34.4	
	345.2	92.2	
<u>Condition 2:</u>	229.4	100.0	
<u>Ensemble OG out</u>	73.8	32.2	
<u>Rucksack load</u>	125.0	54.5	
<u>Zip down from waist</u>	93.8	40.9	
	218.8	95.4	
<u>Condition 4:</u>	274.6	100.0	
<u>Ensemble white out</u>	80.6	29.4	
<u>ALICE combat load</u>	160.0	58.3	
<u>Zip down from waist</u>	107.4	39.1	
	267.4	97.4	
<u>Alternate Procedure</u>			
<u>Condition 3:</u>	215.2	100.0	
<u>Ensemble OG out</u>	88.0	40.9	
<u>ALICE combat load</u>	131.6	61.2	
<u>Zip up from ankle</u>	72.8	33.8	
	204.4	95.0	

TABLE 2
Simulated Urination Tests: Individual Measurements

		Individual Times, By Subject (Seconds)				
<u>NARADCOM Procedure</u>		§ 27	§ 17	§ 2	§ 21	§ 8
<u>Condition 1:</u>	Total time	239	406	282	524	422
	Time to Ready	74 (31%)	185 (46%)	137 (49%)	175 (33%)	153 (36%)
	Insert exposure time	0 (0%)	331 (82%)	41 (15%)	325 (62%)	385 (91%)
	Bare hand exposure time	239 (100%)	0 (0%)	198 (70%)	185 (35%)	22 (5%)
	Total hand exposure time	239 (100%)	331 (82%)	239 (85%)	510 (97%)	407 (96%)
<u>Condition 2:</u>	Total time	146	210	167	340	284
	Time to Ready	38 (26%)	52 (25%)	73 (44%)	126 (37%)	80 (28%)
	Insert exposure time	4 (3%)	198 (94%)	42 (25%)	109 (32%)	272 (96%)
	Bare hand exposure time	131 (90%)	0 (0%)	109 (65%)	217 (64%)	12 (4%)
	Total hand exposure time	135 (92%)	198 (94%)	151 (90%)	326 (96%)	284 (100%)
<u>Condition 4:</u>	Total time	198	218	172	398	387
	Time to Ready	50 (25%)	55 (25%)	43 (25%)	145 (36%)	110 (28%)
	Insert exposure time	11 (6%)	218 (100%)	47 (27%)	162 (41%)	362 (94%)
	Bare hand exposure time	187 (94%)	0 (0%)	116 (67%)	219 (53%)	15 (4%)
	Total hand exposure time	198 (100%)	218 (100%)	163 (95%)	381 (96%)	377 (97%)
<u>Alternate Procedure</u>						
<u>Condition 3:</u>	Total time	102	170	124	498	182
	Time to Ready	28 (28%)	75 (44%)	53 (43%)	195 (39%)	89 (49%)
	Insert exposure time	84 (82%)	160 (94%)	94 (76%)	138 (28%)	164 (90%)
	Bare hand exposure time	18 (18%)	0 (0%)	0 (0%)	346 (70%)	0 (0%)
	Total hand exposure time	102 (100%)	160 (94%)	94 (76%)	484 (97%)	164 (100%)

common, and conditions are frequent in which frostbite hazard develops in 30 seconds. It must be remembered that, where windchill is a problem, a hand covered only by a single knit wool mitten insert is only slightly less susceptible to frostbite hazard than is a bare hand.

These intolerably long performance times are the direct result of a procedure that is not at all simple and involves a number of maneuvers that are difficult or impossible to perform with an impeded hand. A subject wearing the basic equipment ensemble (Condition 1) had to do the following in order to reach the "Ready" point: Unhook ALICE pistol belt; untie parka hemline cord on right leg; unzip the parka up from the bottom; unzip the field coat from the bottom; pull up parka, field coat, and wool shirt on the right side above the waist line; unhook the arctic trousers suspender loop from the suspender hook; unbutton the right side closure button on the arctic trousers; zip down the right hand slide fastener of the trousers, from the waist; then, holding the trousers flap thus freed to one side against some degree of tension from the left leg hemline tie and the protective mask carrier, proceed in the familiar manner to manipulate the fly openings of the field trousers and long underwear. Figure 6 illustrates the general awkwardness of the situation at this point, and also shows the considerable area of exposure of the thigh that results. Not only is the subject forced to cope with a number of layers of loosened clothing; when wearing the ALICE gear he is also juggling a loosened load-carrying ensemble that continually threatens to fall off, as it did on one occasion.

To restore his clothing following urination, the subject must follow the same general sequence of maneuvers, except that the tasks are more difficult. When the arctic trousers are worn OG side out, the buttoned waist closure is located on the inside of the garment. Though this button can be undone fairly readily, rebuttoning was accomplished by only one subject while wearing wool mitten inserts and at the cost of great difficulty and loss of time. A second problem involved the trouser suspender loop, which was quite difficult to re-hook. This was doubly troublesome when the undressing procedure accidentally resulted in unhooking the underlying field trouser suspender loop as well, which occurred about half of the time. When it did, the right side of the elastic suspender snapped up into the armpit where it was most difficult to recover. Finally, the parka hemline ties, which are readily untied by mittened hands, can be re-tied with ease only by bare hands.

Condition 4 is identical to Condition 1, except that the test garments were worn white side out to test whether the buttoned waist strap closure would indeed be easier to maneuver when located on the outside. The data indicate that this was the case.

Condition 3 involved substitution of a rucksack load for the ALICE in order to examine the significance of the difficulties the subjects had with unhooking and re-hooking the pistol belt and with the instability of the unanchored load-carrying equipment when unhooked. Performance times were markedly reduced when the rucksack load was used. Practice cannot account for this time reduction, inasmuch as the subjects performed with Condition 3 before performing with Condition 4 (essentially the same as Condition 1). In all cases, performance times rose again as the ALICE load-carrying ensemble was restored.

Condition 2 was included to see if one could reduce the performance time by avoiding the whole series of complicated manipulations of clothing at the waistline. This was clearly the most efficient procedure of all in terms of total performance time or of total hand exposure time, but the latter are still unacceptable under severe windchill conditions. Moreover, this procedure resulted in the exposure of almost the whole right leg.



Figure 6. Subject ready for urination. (Both hands are cold exposed [one is bare]. Right thigh is extensively uncovered by arctic trousers. Extensive and awkward effort is required to hold back loose flaps of both arctic trousers and parka.)

If the foregoing discussion of observations on simulated urination exercises seem to be unduly lengthy, it is only because the lack of a fly opening on the experimental arctic trousers forced the wearer to engage in an extremely awkward and potentially hazardous maneuver. The failure to provide a conventional type of opening on these trousers, as earlier recommended, made them wholly unacceptable.

Wrist Closures

The closures at the parka wrist openings were modified in response to the recommendation of the feasibility test report. On the garment used in these tests, a strap and button closure was used. This closure performed quite satisfactorily in keeping the parka arm in place despite the excessive arm length of the garment. However, the closure was not tested to see if it had any tendency to catch on projections when the wearers maneuvered in and out of military vehicles or attempted to operate large pieces of military equipment.

For reversibility, the single strap provided for this closure must be passed through a stitched slit in the cuff. In view of the failure of button-hole stitching in the hood attachment (discussed below), the construction of these slits can be expected to fail early in the life of the garment, even though no such failures were observed in these tests in which a limited usage time was involved.

Leg Closures

Despite the recommendations of the feasibility test report, no ankle closures were installed on the garments used in these tests. Some such closure is really necessary to keep draughts and powdery snow out of the trouser legs. In addition, the medium size trousers are presumably to be available in only one length. Personnel whose waist circumference requires a medium size, but who are unusually short-legged, need some sort of ankle tie to keep the bottoms of the trousers off the ground. Otherwise the garment is exposed to excessive wear and presents a constant tripping hazard. The seeming excessive length of the arctic trousers as presently designed intensifies these problems.

In addition to ankle closures, thigh level ties are recommended for trousers of this particular design. The side-opening slide fasteners are intended to be used to provide ventilation, particularly when the wearer is exercising heavily under less than the most extreme cold conditions. Under such conditions, ties are desirable to keep the trousers thus opened from flapping and catching on vegetation or equipment.

Cold Weather Hood Attachment

The design of the parka collar is in need of much improvement. As noted previously (3), the closure between the parka and hood is far from draught-proof. This, upon examination, proved to be due largely to the extreme suppleness of the parka collar, fabricated only of thin nylon material. The weight of the parka pulls the collar down in distorted loops between the widely-spaced button attachments. This defeats the seal that the overlapping flaps of the hood are designed to provide.

The severe sagging at the collar also puts excessive stress on the buttonholes of the parka collar. As a result, a previously unreported failure of these buttonholes was observed during these tests. A case of this is illustrated by Figures 7 and 8. The buttonhole stitching gave way, the woven nylon material unraveled and frayed excessively and rapidly. This is not acceptable durability for an attachment that was made no more than four times during these tests with new garments.

It is recommended that consideration be given to adding stiffening material to the parka collar. If this kind of treatment does not suffice, it may be necessary to consider modification of the hood as well as to provide either more buttons or a slide-fastener attachment.

Camouflage

Inadequate attention has been paid to the snow camouflage characteristics of the experimental cold weather assembly when worn in the white outward mode. Wrist enclosure buttons, slide fastener pull tabs and drawstrings of olive drab color show quite prominently. These are all small-sized garment structures subject to ready movement that is easily observable (see Figure 9). If the white side of this clothing is to serve successfully as snow camouflage, then all parts of the assembly on the white side should be white.

Fabric Noise and Static Electricity

As previously reported (3), the outer layers of the experimental clothing items generate rustling noise on even slight body movements. Subjects used in this study all objected to this feature as a serious detectability hazard under combat conditions. In addition, the fabric tends to generate static electricity under cold dry conditions, as also reported in (3). In one instance during the present study, this static build-up was sufficient to produce a loud static discharge spark. This is a sharp sound easily detected at a considerable distance; it was also uncomfortable enough to elicit an audible gasp of startlement from the subject. The possibility of static discharge sparks also provides a severe safety hazard to those who must handle gasoline fuels. If this kind of problem presents itself at all under the relatively moderate winter conditions encountered in Maryland, then it must be considered an intolerable feature for garments to be used in very cold regions where static electricity build-up is a constant problem. It is the opinion of the present observers that the kind of material used for the outer layers of the experimental cold weather clothing should be considered wholly unsuitable on the basis of its noise and static electricity characteristics.

Design Concept

The experimental clothing assembly has two fundamental features new to military application: (1) Use of single reversible garments to replace three-piece assemblies; and (2) full length slide-fastener closures on the trouser legs. These features got in all cases a strong favorable response from subjects used in the tests here discussed and also from other military personnel who examined the experimental clothing, but could not be used as subjects for reasons of size. The light weight of the garments and their suppleness are also favorably received features. Together they contribute to reducing the feeling of restrictive bulkiness to any wearer who has had previous experience with extreme cold weather clothing.



Figure 7. Buttonholes on neckband of parka- O.D. side. (Buttonhole stitching has failed completely on upper buttonhole after four experimental trials. Hood is attached to parka and removed twice for each trial. Lower buttonhole shows the severe fraying that occurs in the nylon shell material even before buttonhole stitching fails.)



Figure 8. Buttonholes on neckband of parka- white side. (Illustrates the opposite side of the same buttonholes shown in Figure 7.)



Figure 9. Experimental clothing ensemble worn in camouflage mode. (Clothing ties and slide fastener pulls of O.D. color are much too prominent against the shining white nylon of the parka shell. O.D. buttons on trouser leg closures, not visible in this photograph, are equally prominent.)

Labeling

The experimental garments as supplied lacked labels identifying the garments and indicating size. Ultimately these will have to be added, but the reversibility characteristic of these items prevents this from being accomplished in the usual manner; i.e., placed inside the garment. For the parka, it is suggested that labeling can be placed inside the edge of one of the pockets. There is no way to place concealed labels on reversible pocketless trousers. The most practical solution appears to be to place labels on the waistline on the rear of the trousers, where the overhanging parka will cover them. The least conspicuous treatment would be to use subdued (black) lettering on the OG side of the trousers.

CONCLUSIONS

A human factors evaluation of an experimental two-piece reversible extreme cold weather clothing ensemble leads to the following conclusions:

1. The principle new design features of the ensemble are highly acceptable to military subjects who have worn and handled them. These features are the lightweight, single piece, reversible garments of the ensemble, and the side opening full-length slide fasteners on the trousers.
2. Subjects were able to don and doff the parka and trousers quickly and without difficulty.
3. The improved method of installation of the slide fasteners, with beaded edges on the fastener overlays, has satisfactorily solved the problem of fastener jamming.
4. The fit of the garments, with respect to basic cut, is satisfactory. The parka arms and the trouser legs appear to be too long.
5. Omission of a front fly opening on the trousers is completely unacceptable. Without a conventional opening, urination becomes an awkward, time-consuming, and potentially hazardous process.
6. The reversible button and strap wrist closures function satisfactorily to keep the parka arms in position at the wrist level.
7. The lack of ankle closures on the trousers is unacceptable. Thigh level ties on the trousers are desirable to control flapping when the side-opening trousers are opened for ventilation.
8. Construction of the parka neck is poor. The weight of the garment causes sagging between widely-spaced button attachments resulting in poor seal with the hood and excessive strain on buttonholes.
9. The method of edge stitching on buttonholes is defective. Buttonhole construction failed in as little as four wearings.
10. When the ensemble is worn in the camouflage mode (white side out), too many OG components are visible.

11. The outer fabric of the ensemble garments generates noise both by frictional rustling and by static electricity discharge sparks. The sparks in turn comprise a serious hazard to gasoline fuel handlers.

RECOMMENDATIONS

1. The lengths of the parka arms and of the trouser legs need to be shortened.
2. The parka trousers need to be provided with a conventional front fly opening with enough overlap to prevent draught penetration.
3. The trousers need to be provided with ankle closures and preferably with thigh level ties.
4. Construction of the parka neck needs to be redesigned to provide an adequate draught-free closure with the attached hood.
5. The method of stitching buttonhole edges needs substantial improvement to prevent failure.
6. OG-colored garment accessories need to be eliminated from the garment as worn in the camouflage mode.
7. The outer layer fabric of the two test garments should be replaced by a material that eliminates or sharply reduces friction-generated noise and static electricity buildup.

REFERENCES

1. Corona, B.M., Jones, R.D., Randall, R.B., Ellis, P.H., & Bruno, R.S. Human factors evaluation of two proposed Army infantry/Marine fragmentation protective systems (April through June 1974). Technical Memorandum 24-74, U.S. Army Human Engineering Laboratory, Aberdeen Proving Ground, MD, October 1974.
2. Telephone communication between Mr. Stanley Shurtleff, Clothing Branch, Clothing, Equipment and Materials Engineering Laboratory, NARADCOM, Natick, MA, and Mr. B. Corona, Personnel Clothing, Equipment and Life Support Systems Team, Systems Performance and Concept Directorate, U.S. Army Human Engineering Laboratory, Aberdeen Proving Ground, MD, December 1976.
3. Weinbaum, P.F. Feasibility test of parka and trousers, extreme cold weather (arctic), reversible. Final Letter Report. U.S. Army Arctic Test Center, APO Seattle 98733, 7 June 1974.